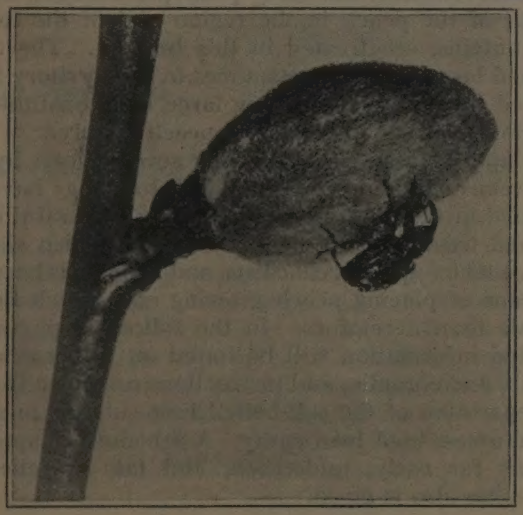
SPRAYING PEACHES FOR THE CONTROL OF BROWN-ROT, SCAB, AND CURCULIO

W. M. SCOTT
Formerly of the Bureau of Plant Industry
and
A. L. QUAINTANCE
Of the Bureau of Entomology

IMPERIAL BUREAU OF MYCOLOGY
28 JUN. 1921



FARMERS' BULLETIN 440
UNITED STATES DEPARTMENT OF AGRICULTURE

Contribution from the Bureau of Plant Industry, W. A. TAYLOR, Chief, and the Bureau of Entomology, L. O. HOWARD, Chief.

Washington, D. C. Issued March 27, 1911; abridged reprint, April, 1918

Show this bulletin to a neighbor. Additional copies may be obtained free from the Division of Publications, United States Department of Agriculture

WASHINGTON : GOVERNMENT PRINTING OFFICE : 1918

PEACH SCAB, BROWN-ROT, AND THE PLUM CURCULIO, the three principal troubles of the fruit of the peach in the region east of the Rocky Mountains, are treated in this bulletin. The combined losses from these sources in the territory indicated have often been very large and constituted a serious obstacle to successful peach culture.

Experiments carried out over several years by the Bureaus of Plant Industry and Entomology have resulted in the development of a very successful combined treatment for these affections, which was at once taken up by orchardists, and which has been the means of placing peach growing on a much firmer basis than heretofore. In the following pages detailed information will be found on the brown-rot, scab, and curculio, and instructions are given for the preparation of the self-boiled lime-sulphur mixture and arsenate of lead spray. A schedule of applications for early, midseason, and late varieties of peaches also is given.

SPRAYING PEACHES FOR THE CONTROL OF BROWN-ROT, SCAB AND CURCULIO.[1]

CONTENTS.

	Page.		Page.
Losses from brown-rot, peach scab, and the plum curculio	3	Effect of spraying on the quality of the fruit	17
Brown-rot	5	Effect of the self-boiled lime-sulphur wash on scale insects	18
Peach scab	8	Preparation and use of the spray	18
The plum curculio	10	Schedule of applications	23
Experience of fruit growers in spraying	15		

LOSSES FROM BROWN ROT, PEACH SCAB, AND THE PLUM CURCULIO.

The peach-growing industry in the United States has become a very important one, being second in extent among fruits only to the cultivation of the apple. According to the 1910 census, there were in that year in the territory east of the Rocky Mountains, which is subject to the troubles treated in this bulletin, approximately 84,000,000 bearing peach and nectarine trees, and 35,000,000 trees not yet of bearing age. According to the same census the gross value of the crop for 1909 for this territory was approximately $23,000,000. Since the nectarine is a relatively unimportant crop in this country, these statistics refer largely to the peach.

Although many insects and parasitic fungi occur on the peach, comparatively few are of much economic importance. Of the diseases of the peach, the brown-rot[2] and scab, or black-spot,[3] are responsible for practically all of the damage to the fruit crop and the insect injury is limited almost entirely to the attack of one species, the plum curculio.[4]

The brown-rot probably causes more loss to peach growers than all other diseases of the peach combined, with perhaps the exception of "yellows," which kills the trees outright. In the South the brown-

[1] In conducting the experiments and demonstrations on which this bulletin is based the writers were assisted by E. W. Scott and the late E. L. Jenne, of the Bureau of Entomology, and by Leslie Pierce and G. W. Keitt, of the Bureau of Plant Industry.

[2] *Sclerotinia cinerea* (Bon.) Wor.

[3] *Cladosporium carpophilum* Thüm.

[4] *Conotrachelus nenuphar* (Herbst).

rot often causes the destruction of half or even practically all of the crop, and throughout the territory under consideration the annual shrinkage in yield is perhaps 25 to 35 per cent of the crop, representing a valuation of about $3,000,000 to $4,000,000. Although the brown-rot is always present in the peach orchards of humid sections, causing a rotting of a certain proportion of the fruit, it becomes notably destructive only under certain weather conditions, when within a period of 10 days or 2 weeks it will spread so rapidly as to result in the destruction of practically the entire crop. Such disastrous outbreaks are likely to occur if moist, humid weather prevails as the fruit begins to ripen. The brilliant prospects of the orchardists are thus within a few days obliterated as if by fire.

The peach scab is the only other destructive disease of the fruit in the eastern United States, and, while it does not occur in such sudden and disastrous outbreaks, the sum total of the injuries caused by it are very important, resulting in a shrinkage in crop values of perhaps $1,000,000 annually. This disease occurs all over humid America where the peach is grown and is especially troublesome east of the Allegheny Mountains. It not only renders much of the fruit unfit for market, but so mars the appearance of the marketed fruit as to reduce its value.

The plum curculio is of scarcely less importance in its relation to the successful production of the peach than the diseases above mentioned. By its punctures of the fruit in feeding and egg laying and the injury resulting from the larvæ, or grubs, within the fruit it brings about a reduction in yield of a valuation amounting to perhaps not less than $3,750,000 annually. The puncturing of the fruit also greatly favors the brown-rot, and curculio control is a prime essential in preventing losses from this malady. Although the plum curculio is very generally distributed eastward of the Rocky Mountains, it is especially abundant in the Middle and Southern States. During years of full fruit crops its injuries are less important, simply more or less thinning the fruit; but when the crop is light little fruit may escape its ravages.

The troubles mentioned have more than kept pace with the development of the peach-growing industry, and the cultivation of this crop, especially in the South, has become more and more hazardous. Practical means for their control have, therefore, been most urgently needed, and much attention has been given by investigators of the Department of Agriculture and of the various agricultural experiment stations to supply this want. While it has been possible by the use of certain sprays, such as Bordeaux mixture and Paris green, effectively to reduce these troubles, the sensitiveness of the foliage and fruit of the peach has practically prevented their employment, and the peach grower has been almost helpless against them. A

spray effective in the control of these troubles and which at the same time may be used with perfect safety on the trees and fruit has been the most important requirement to place the industry on a reasonably secure foundation.

Experiments begun by the Bureau of Plant Industry about 1909 and since carried out under varying climatic and other conditions in different parts of the eastern United States have established beyond question the effectiveness of the self-boiled lime-sulphur wash for the control of the fungous diseases mentioned. Earlier experiments by the Bureau of Entomology already had shown that by the proper use of arsenate of lead the curculio could be largely controlled, although on account of danger of foliage injury its use had not been recommended unqualifiedly. Cooperative experiments between the two bureaus have shown that the fungicide and arsenical may be used as a combined spray with satisfactory results in controlling these troubles and without injury to the fruit and foliage of the peach. Hence, there is available a satisfactory method for the control of these three serious obstacles to successful peach culture.

BROWN-ROT.

NATURE AND CAUSE OF THE DISEASE.

Brown-rot is a fungous disease which affects the stone fruits, such as the peach, plum, and cherry, and to a less extent some of the pome fruits, such as the apple, pear, and quince, producing a so-called rot of the fruit and blight of the twigs. On stone fruits it is caused by a fungus known to botanists as *Sclerotinia cinerea* (Bon.) Wor. Brown-rot is the common name usually applied to the disease, but "monilia," the generic name of the imperfect stage of the fungus, is often used by some of the older fruit growers.

The disease appears on the fruit as a small, circular, brown spot, which under moist, warm conditions enlarges rapidly, soon involving the entire fruit in decay (fig. 1). The spots usually do not become sunken, and the fruit remains plump until almost entirely decayed. The fungus growing in the tissues of the fruit breaks through the skin, forming small, grayish tufts of spore-bearing threads. These tufts, although few on young spots, soon become so numerous as to give the diseased area a grayish, moldly appearance, which is responsible for the term "peach mold" sometimes applied to the disease. The spores which are produced in great abundance by these fungus tufts are blown by the wind and carried by insects and birds from fruit to fruit, tree to tree, and orchard to orchard. Finding lodgment on the fruit under favorable conditions of temperature and moisture, these spores germinate, producing a fungus

growth, which ramifies and kills the tissues. These dead tissues turn brown, and the fungus breaks through the surface, producing another crop of spores. The process is very rapid, only a few days intervening between one generation of spores and another.

DAMAGE TO THE PEACH.

Although the young fruits may become affected soon after the petals are shed, as a rule no marked outbreak occurs until the fruit is half grown or larger, and the greatest destruction is wrought at harvest time. The fruit crop may reach maturity in perfect condition and yet be destroyed before it can be picked. Moreover, the fruit may become infected in transit or after reaching the market. It is no uncommon experience among peach growers to have a carload of peaches leave the orchard apparently in good condition and arrive on the market specked and practically worthless, owing to the brown-rot fungus. Through handling by pickers and packers some fruit in every package may become contaminated with spores from a few diseased fruits in the orchard. Enough moisture usually develops in the car to germinate the spores, and if the refrigeration is poor the fruit is likely to go down in partial or total decay before reaching the consumer.

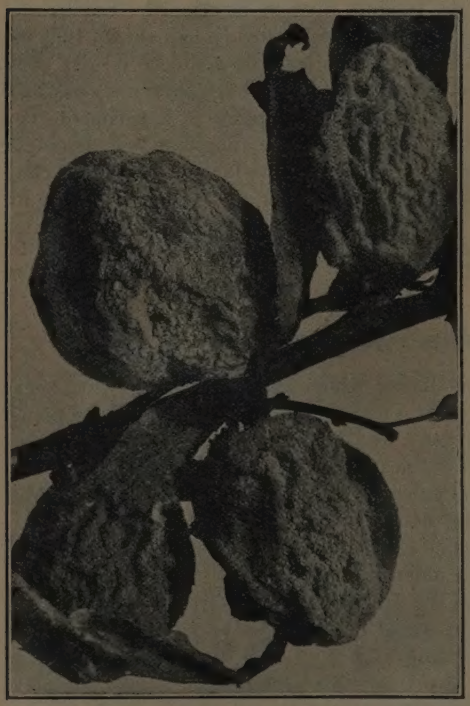


FIG. 1.—Peaches entirely destroyed by brown-rot, showing gray masses of spores of the fungus.

The fungus also attacks the blossoms and extends from these into the fruit-bearing twigs, often girdling them. In a wet spring the fruit crop may be thus materially reduced, although this form of attack is only occasionally serious. In like manner the fungus may extend from diseased fruits into the twigs. Following an outbreak

of brown-rot on the fruit, these twig infections may become so severe as to give the trees a blighted appearance.

WINTER STAGE AND SOURCE OF INFECTION.

The infected fruits largely drop to the ground, although many of them hang on the trees for months. They become dried and shriveled, and at this stage are known as brown-rot mummies. The fungus passes the winter in these mummies, which form the chief source of infection for the new fruit crop. When moistened by spring rains, the mummified fruits on the trees and on the ground become covered with fruiting tufts of the fungus, producing countless numbers of spores.

After 18 months, or at the end of the second winter, about the time peach trees are in bloom, there arise from the mummies on the ground, partly or entirely covered with soil, fruiting bodies representing the perfect stage of the fungus. These are dark-brown, somewhat bell-shaped disks, resembling toadstools. In them are produced an abundance of ascospores, which rise in the air and are wafted by the wind. These, as well as the summer spores (conidia), serve to infect the blossoms and young fruits. The propagation of the fungus being thus so abundantly provided for, it is not surprising that a crop of fruit may be destroyed without much warning.

INFLUENCE OF THE WEATHER AND INSECTS.

In sections where the brown-rot is prevalent the spores are practically omnipresent, and only favorable conditions for their germination and the rapid growth of the fungus are required to start an outbreak of the disease. The most important factor in the dissemination of brown-rot is excessive moisture in the form of rain, which not only favors the production and germination of the spores and the growth of the fungus, but renders the fruit soft and watery, and therefore more susceptible to the disease. High temperatures also favor the disease, although the fungus grows readily in mild summer temperatures. Prolonged cloudy weather with frequent light showers is more dangerous than a hard rain followed by clearing. Warm, muggy weather, when the fruit is maturing, is often disastrous to the crop.

Insects, especially the curculio and certain plant-bugs, play an important part in the distribution of the spores and the infection of the fruit. Although the fungus under favorable conditions apparently is able to pass readily through the unbroken skin of the fruit, it is aided greatly by insect abrasions. In the process of feeding and egg laying the curculio punctures the skin of the fruit, opening the way for the fungus and in many cases perhaps actually inserting the

spores. This insect may render spraying for brown-rot partially ineffective by breaking the sprayed skin of the fruit, thus exposing the flesh to attack. In the treatment of the disease it is, therefore, important to combine an insecticide with the fungicide in order to destroy the beetles.

TREATMENT.

Experiments conducted by the Bureau of Plant Industry during the past eight or nine years have shown conclusively that this disease can be controlled by the use of self-boiled lime-sulphur mixture.

A schedule of applications for the combined treatment of brown-rot, scab, and curculio is given on pages 23 and 24 of this bulletin.

PEACH SCAB.

ECONOMIC IMPORTANCE OF THE DISEASE.

Of the diseases affecting the fruit of the peach, scab is second only to brown-rot in economic importance; in fact, it is more destructive

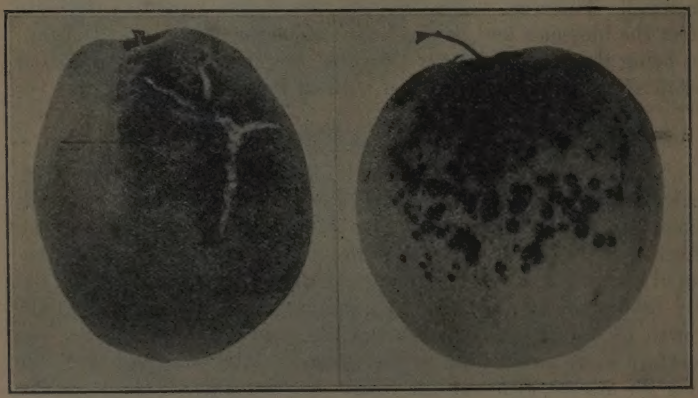


FIG. 2.—Peach scab on Elberta peaches, showing spots and cracks caused by the disease.

than brown-rot in some of the mountain districts. It dwarfs the fruit and causes premature dropping, thereby reducing the yield; it ruptures the skin, opening the way for brown-rot attack, and mars the appearance of the fruit, thus lowering the grade and reducing the market value. The disease is common wherever peaches are grown east of the Rocky Mountains, scarcely an orchard being entirely free from it. In some cases, especially in a dry season, only a small percentage of the fruit may become infected and that with only a few small harmless spots, while in other cases the entire crop may become so badly affected as to be unmarketable. If both the loss in the

orchard and the reduction in market value are considered, it seems evident that a loss of 10 per cent of the total value of the peach crop in the eastern United States is caused by peach scab.

THE NATURE AND CAUSE OF THE DISEASE.

The name commonly applied to this disease is "peach scab," but it is also known as "black spot" and "freckles" and in some districts it is often improperly called "mildew." It is caused by a fungus[1] which grows in the skin of the fruit, producing small, circular, dark-

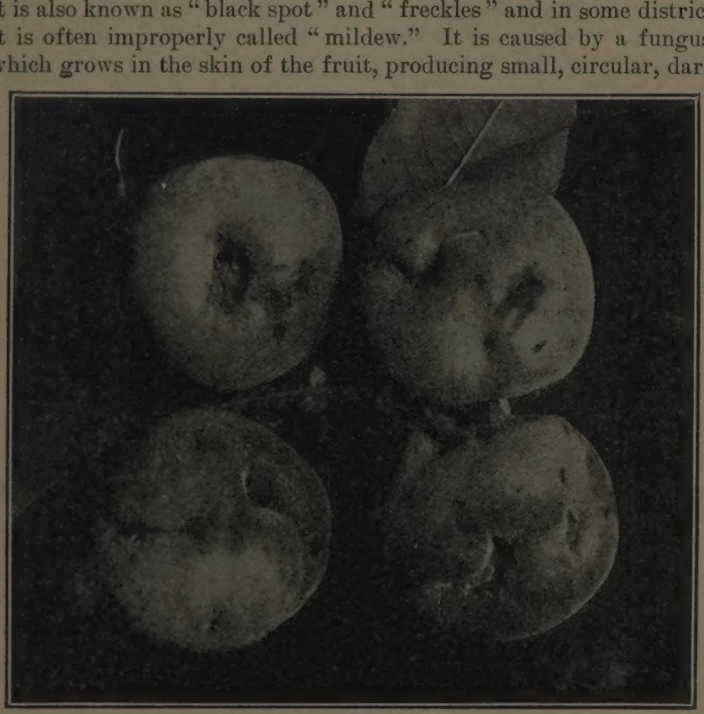


FIG. 3.—Deformed ripe peaches resulting from feeding and egg-laying punctures of the plum curculio.

brown spots. When numerous, these spots give the fruit a smutty or blackened appearance and cause the skin to crack (fig. 2). Fruit badly affected does not reach normal size and often drops prematurely.

The fungus also attacks the twigs, producing brown spots, in which it passes the winter. These spots are very common in peach orchards, but apparently they do little damage to the twigs. During the spring or early summer the fungus growing in the spots produces olive-brown spores which serve to infect the young peaches. Similar spores are also produced on the fruit spots.

[1] *Cladosporium carpophilum* Thüm.

THE SUSCEPTIBILITY OF VARIETIES.

There is a considerable difference in varieties as to their susceptibility to peach scab. In general the late varieties are much more susceptible than are the early varieties. This is due, in part at least, to the fact that the fruit of the late-maturing varieties is exposed to infection over a longer period and the opportunity for the development of the disease is greater. Of the commercial varieties, the Heath is perhaps the more susceptible; in fact, the disease has almost prohibited the growing of this variety except in a small way. The Bilyeu variety is also badly affected and the disease has restricted its culture to high, well-drained locations. The Salway, Smock, and most of the other varieties that ripen after the Elberta usually suffer rather severely from this disease, while the Elberta may be considered somewhat less susceptible, although the crop of this variety often becomes badly diseased. The varieties that ripen earlier than Elberta are as a rule only slightly or moderately affected. This is especially true of the Carman, Hiley, Champion, and Belle. On the other hand, the Mountain Rose and Early Rivers are quite susceptible to the disease.

TREATMENT.

The development of the self-boiled lime-sulphur mixture as a fungicide has made possible the control of the scab without injury to the fruit or foliage. The injury produced by this disease may be almost entirely prevented at a small cost. This has been abundantly demonstrated through experiments conducted by the Bureau of Plant Industry. The schedule of applications for the control of this disease, together with the brown-rot and curculio, is given on pages 23 and 24 of this bulletin.

THE PLUM CURCULIO.[1]

WHAT THE CURCULIO IS.

The curculio is a small snout-beetle of the family Curculionidae, a family which contains many species of economic importance. The adult insects vary somewhat in size, but will average about three-sixteenths of an inch in length. On the title page of this bulletin is shown a beetle on a newly set peach, considerably enlarged. In the course of its growth the insect passes through four stages, namely, the egg, larva, pupa, and adult. The larva, or grub, is the small whitish worm frequently found in ripe peaches, plums, and cherries and is well known to lovers of these fruits.

[1] *Conotrachelus nenuphar* (Herbst).

There are many common names for this insect, such as the "plum curculio," "plum weevil," "peach curculio," "peach worm," "fruit weevil," "little Turk," "curculio," etc. The name here used, however, is perhaps best fixed in literature on economic entomology and has been adopted for this species by the American Association of Economic Entomologists.

The plum curculio is a native American insect and fed originally, as it feeds at the present time, on wild plums and other wild fruits, especially Crataegus. Its injuries were noted as long ago as 1736, and it was the subject of an extended article published in 1804. Our

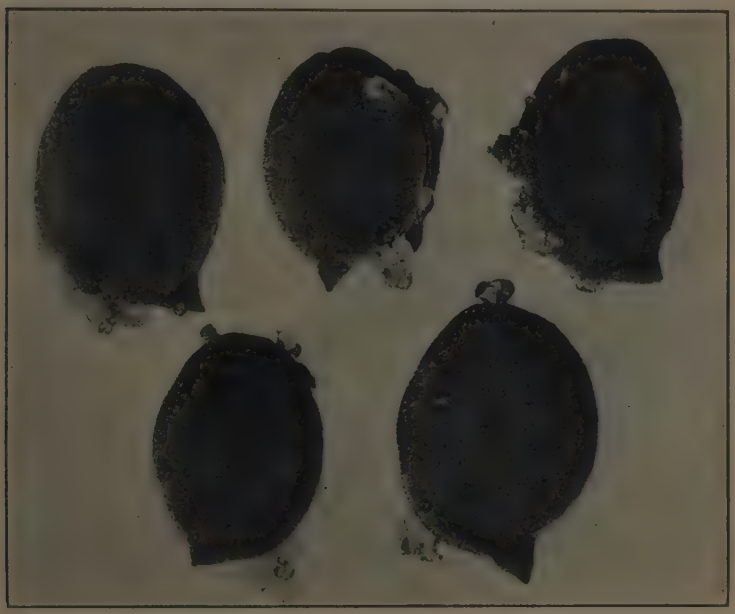


FIG. 4.—Peaches showing the exudations of gum from plum curculio punctures.

early horticultural literature abounds with references to its depredations, especially to plums, which apparently were grown with the greatest difficulty.

So far as is known, the plum curculio is still confined to North America, ranging from southern Canada south to Florida and Texas and west to about the one-hundredth meridian. It appears to be restricted in its westward spread by the more arid climate of the Great Plains region. It is probably present throughout its entire area of distribution, but is especially abundant in the Central and Southern States.

FOOD PLANTS AND CHARACTER OF INJURY.

Practically all stone and pome fruits, such as peaches, plums, apricots, nectarines, cherries, apples, pears, etc., are used by the curculio for feeding and egg-laying purposes. Injury is done by both the adult and larva. The former punctures the fruit in feeding and in egg laying, and the grubs live within the fruit and spoil it for market or other purposes. The character and extent of injury vary with different fruits, and while the present paper deals with the insect as an enemy of the peach the statements here made are fairly applicable to other stone fruits, such as plums, cherries, apricots, and nectarines.

Most of the peaches punctured while small soon fall from the effect of the injury or on account of the presence of the developing grubs. After a peach is of some size, about one-third grown, most of the larvæ apparently are unable to develop successfully in it, owing to its vigorous growth. There is a considerable period, therefore, when the curculio is able to inflict little damage to vigorous-growing peaches, though the fruit may be more or less scarred by the feeding and egg punctures, from which gum may exude, especially during moist weather (figs. 3 and 4). As stated elsewhere, these punctures and the exudations of gum greatly favor the brown-rot, forming a nidus for spores of the fungus and furnishing an easy point of infection. After the period of rapid growth of peaches has passed and the ripening process has begun, the curculio larva is able to develop readily in the fruit and, as the beetles are still ovipositing when early and midsummer varieties are ripening, wormy ripe peaches are often to be noted at picking time. The loss caused by worminess of fruit (fig. 5), while often quite important, is perhaps less so than that resulting from the "stings" which deform and scar the fruit. Wormy fruit and that which is scarred to any extent ripen prematurely, as a rule, and in untreated orchards may constitute a considerable proportion of the crop.

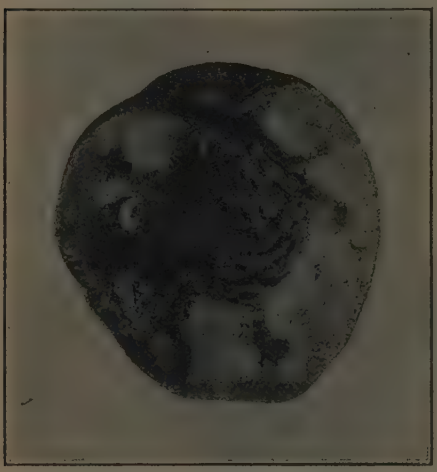


FIG. 5.—Peach infested with plum curculio larva, or grub.

LIFE HISTORY AND HABITS.

How the curculio passes the winter.—The curculio passes the winter in the adult or beetle stage under trash in orchards, along fences, terraces, etc., but especially in woods adjacent to orchards. The beetles come out of hibernation in the spring at about the blooming period of the peach, feeding at first upon the buds and foliage and later also upon the fruit.

Occurrence in orchards.—The invasion by the beetles of orchards in spring and the effect on their abundance of neighboring woods have been investigated several times. Much may be done to reduce their numbers by keeping the orchards and surroundings free from trash. Where practicable, it will be desirable to burn over in early spring woods adjacent to orchards in order to destroy the beetles hibernating there.

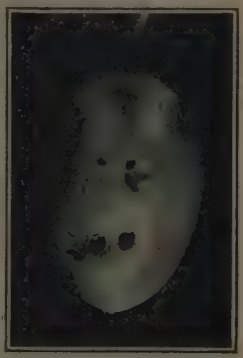


FIG. 6.—Egg and feeding punctures of the plum curculio on a young plum.

Egg-laying habits.—Peaches are less suitable for the egg-laying purposes of the curculio than smooth-skinned fruits, such as plums, apples, etc. Observations by the late E. L. Jenne indicate that the fuzz may be so copious on young peaches as to prevent the puncturing of the skin by the beetle. He observed that eggs were frequently deposited at the bottom of the tubular boring excavated down in the fuzz as far as the skin of the peach, which was usually scraped somewhat, later resulting in a russet spot on the fruit. In older fruit, however, the female is able to place her eggs under the skin in about the usual manner. In ovipositing, a hole is first excavated through the skin and into the flesh, about as deep as her snout will reach. Turning around, an egg is inserted by means of the ovipositor. Once more turning around, the snout is used to push the egg into the egg cavity and to fill it with bits of surrounding tissue. The next step is to cut the characteristic crescentic slit at one side of the egg cavity, the excavation extending back under the egg to prevent its being crushed by the rapid growth of the fruit. Egg and feeding punctures on a newly set plum are shown in figure 6, much enlarged.

Period of oviposition and number of eggs laid.—Egg laying begins as soon as the young fruit is of sufficient size and may continue for several months, depending upon the vitality of the individual beetles. Most of the eggs, however, are laid during the first six or eight weeks after egg laying begins.

Time spent in the fruit.—Records of the time spent in the fruit as egg and larva have been determined for many individuals and in

various localities, including Illinois, the District of Columbia, western New York, Georgia, Arkansas, and Michigan. In all localities the majority of the larvæ emerged within three weeks after the eggs were laid, and, with one exception, emergence had practically ceased by the close of the fourth week.

Time spent in the soil.—When full grown the larva deserts the fruit and burrows below the surface of the soil. Practically none of the larvæ go deeper than 3 inches and the great majority penetrate not more than 2 inches. A small cell is made where the pupa stage is passed and where transformation to the adult or beetle occurs. Some days are spent in the soil by the larva before change to the pupa, and the newly formed adult may not emerge for several days

FIG. 7.—Crop from four Salway trees sprayed twice, Okonoko, W. Va. Scabby, unsalable fruit in single basket on the left; remainder of the crop sound.

or even weeks, especially if the ground be dry. The effect of a shower, however, is to bring the beetles of the new generation out in numbers.

Time required for transformation from egg to adult.—The average time spent in the fruit for the numerous localities investigated proved to be 19.48 days, and the average time spent in the ground was found to be 30.89 days, giving an average life-cycle period for the insect of 50.27 days.

Habits of beetles from emergence until hibernation.—After emergence beetles of the new generation feed upon various fruits and plants until fall, when they enter hibernation quarters, appearing the following spring, as already stated. While there is some evidence to indicate that there may be a small second generation in the South,

this will be comparatively insignificant and for practical purposes the insect produces but one well-defined generation annually. The beetles which develop in a given summer live over the following winter, ovipositing during the following spring and summer, and gradually die off, until by early fall practically all of them have disappeared. The life of the more hardy beetles is thus seen to be some 12 or 14 months.

EXPERIENCE OF FRUIT GROWERS IN SPRAYING.

Following the early recommendations of the United States Department of Agriculture, a large number of fruit growers adopted the combination treatment for the scab, brown-rot, and curculio. In fact the practice has rapidly become universal. In connection with

FIG. 8.—Crop from four unsprayed Salway trees, Okonoko, W. Va. Sound fruit in three baskets on the left; remainder of the crop too badly scabbed to be salable.

the department's experiments at Fort Valley, Barnesville, and Baldwin, Ga., in 1910, an effort was made to give personal instruction to as many orchardists as possible in order to start them in the work, and by visits and by correspondence assistance was rendered to growers in other parts of the State. Thus at Fort Valley the Hale Georgia Orchard Co. sprayed three times its entire bearing orchard of about 100,000 trees. The same schedule of treatments was also adopted by Mr. W. C. Wright in his orchard of 60,000 trees, and by others in the immediate neighborhood. At Marshallville, Ga., the treatment was adopted by Mr. S. H. Rumph and other leading growers, the total number of trees sprayed in this general section aggregating about a million.

At Barnesville, Ga., practically all of the large orchardists used the combined spray, and the operations involved not less than 500,000 trees. At Baldwin, Ga., some of the leading growers sprayed not less than 100,000 trees. Messrs. Stranahan Bros., of Warm Springs, Ga., began spraying about 1908 and were among the first large peach orchardists to adopt the lime-sulphur treatment even before it was out of its experimental stage. Around Adairsville and at numerous other points in Georgia spraying was adopted by the leading growers, at least 2,000,000 trees for the State as a whole being sprayed. Considering all of the southeastern States it is probable that in this territory 3,000,000 trees were sprayed during 1910.

FIG. 9.—Crop from four Salway trees sprayed twice, Okonoko, W. Va. Rotten fruit in upturned basket on the left; remainder free from rot.

Considerable spraying has also been done by peach orchardists in West Virginia, western Maryland, and Pennsylvania, including a total of perhaps 1,000,000 trees. The treatment has been adopted by some growers in Illinois, Missouri, and Arkansas, aggregating about 500,000 trees, making on a conservative estimate a grand total of 4,500,000 to 5,000,000 trees sprayed during 1910 with the self-boiled lime-sulphur wash and arsenate of lead.

The writers have been able personally to examine some of these orchards, and have had reports from many of the orchardists regarding the results of the treatment. So far as it has been possible to determine, the results have been uniformly satisfactory and the slight injury from the spray comparatively unimportant. (See figs. 7, 8, 9, and 10.)

EFFECT OF SPRAYING ON THE QUALITY OF THE FRUIT.

The good results from the treatment do not end with the control of the curculio, scab, and brown-rot. The sprayed fruit is as a rule somewhat larger, much more highly colored, and firmer than unsprayed fruit. It keeps longer, carries to the market in better condition, and brings better prices. A carload of Elberta peaches shipped from Baldwin, Ga., on July 29, 1910, contained 166 crates of sprayed fruit and 324 crates of unsprayed fruit. This fruit was sold on the New York market on August 2, the 166 crates of sprayed fruit bringing $2.50 per crate, while the 324 crates of unsprayed fruit brought an average of $1.75 per crate, a difference of 75 cents per crate in favor of the sprayed fruit.

FIG. 10.—Crop from four unsprayed Salway trees, Okonoko, W. Va. Fruit in six baskets on right affected with brown-rot; remainder free from rot, but scabby.

The effect of the treatments is fairly to cleanse the fruit from disease and to put it in a more or less sterilized condition, adding greatly to its keeping quality. This superiority of sprayed as against unsprayed fruit is one of the marked benefits and has been noted by all growers who have adopted the treatment.

On July 14, 1910, sprayed and unsprayed Elberta fruit in the Hale orchard at Fort Valley, Ga., was picked and packed for a shipping test, but owing to a car shortage was not shipped. There were 64 crates of unsprayed fruit and 400 crates of sprayed fruit. This fruit was stacked out on the ground where it remained in the sun and during occasional showers of rain until July 18 (4 days) and then

6 crates of each lot were examined for brown-rot. It was found that 62.7 per cent of the unsprayed fruit had rotted, while only 8 per cent of the sprayed fruit was so affected, showing conclusively the better keeping qualities of the latter.

EFFECT OF THE SELF-BOILED LIME-SULPHUR WASH ON SCALE INSECTS.

Observations and experiments go to show that, when used as a summer spray, the effect of the self-boiled lime-sulphur wash on the control of scale insects which may be present on the trees, especially the San Jose scale, is important. While to secure the best results in the control of scale insects it would be desirable to coat the limbs and twigs more thoroughly than is accomplished in ordinary summer spraying, nevertheless in the course of the work as practiced against the curculio, brown-rot, and scab noticeable good is accomplished. Although the spray is not strong enough to kill many of the adult scale insects, it is effective to an important extent in bringing about the death of the young scales. Experiments made by the Bureau of Entomology in the use of the self-boiled lime-sulphur wash as a summer spray for the San Jose scale[1] have shown that two or three applications will result in a marked improvement in the condition of the trees by fall. The effect of the wash is to prevent the settling of the young scales upon the twigs and branches, so that by the close of the season the trees are largely free of insects.

PREPARATION AND USE OF THE SPRAY.

Spraying for the brown-rot, scab, and curculio does not differ in principle from the usual spraying practices. It is essential that an efficient spraying outfit be employed, so that the work may be done expeditiously and with thoroughness. Where the orchard interest is at all important it will be desirable to employ a power sprayer, such as a gasoline or compressed-air outfit. Excellent work, however, may be done with the ordinary barrel sprayer, which is suitable for orchards of a few hundred trees. In applying the spray, all parts of the tree should be reached. This is especially important in the first application, which is directed principally against the plum curculio. The purpose should be thoroughly to coat the foliage, twigs, and young fruit to insure to the fullest extent possible the poisoning of the beetles. The same precautions as to poisoning the foliage, fruit, and buds are also essential in making the second application, as the beetles are still very numerous, feeding and ovipositing freely. This is also the most important application for the prevention of scab infection, which is prevented only by thoroughly coating

[1] Reported in the Journal of Economic Entomology, vol. 2, p. 130.

the young fruits. In subsequent applications the efforts should be directed more toward coating the fruit with the spray to protect it from brown-rot infection, especially as it beings to ripen.

The schedule of applications (pp. 23–24) takes account of the ripening period of the principal commercial varieties of peaches. Applications made later than a month or six weeks before picking time are likely to result in the fruit being more or less spotted with the spray when harvested, somewhat marring its appearance for market purposes. This danger can be largely avoided by the use of nozzles which throw a mistlike spray, coating the fruit with very fine dots rather than with large blotches.

DIRECTIONS FOR THE PREPARATION OF SELF-BOILED LIME-SULPHUR WASH.

The standard self-boiled lime-sulphur mixture is composed of 8 pounds of fresh stone lime and 8 pounds of sulphur to 50 gallons of water. In mild cases of brown-rot and scab a weaker mixture containing 6 pounds of each ingredient to 50 gallons of water may be used with satisfactory results. The materials cost so little, however, that one should not economize in this direction where a valuable fruit crop is at stake. Any finely powdered sulphur (flowers, flour, or "commercial ground" sulphur) may be used in the prepation of the mixture.

In order that the best action from the lime may be secured, the mixture should be prepared in rather large quantities, at least enough for 200 gallons of spray, using 32 pounds of lime and 32 pounds of sulphur. The lime should be placed in a barrel and enough water (about 6 gallons) poured on almost to cover it. As soon as the lime begins to slack the sulphur should be added, after it has been run through a sieve to break up the lumps, if any are present. The mixture should be stirred constantly and more water (3 or 4 gallons) added as needed to form at first a thick paste and then gradually a thin paste. The lime will supply enough heat to boil the mixture several minutes. As soon as it is well slaked water should be added to cool the mixture and prevent further cooking. It is then ready to be strained into the spray tank, diluted, and applied.

The stage at which cold water should be poured on to stop the cooking varies with different limes. Some limes are so sluggish in slaking that it is difficult to obtain enough heat from them to cook the mixture at all, while other limes become intensely hot on slaking, and care must be taken not to allow the boiling to proceed too far. If the mixture is allowed to remain hot for 15 or 20 minutes after the slaking is completed, the sulphur gradually goes into solution, combining with the lime to form sulphids, which are injurious to peach foliage. It is therefore very important, especially with hot

lime, to cool the mixture quickly by adding a few bucketfuls of water as soon as the lumps of lime have slaked down. The intense heat, violent boiling, and constant stirring result in a uniform mixture of finely divided sulphur and lime, with only a very small percentage of the sulphur in solution. It should be strained to take out the coarse particles of lime, but the sulphur should be carefully worked through the strainer.

DIRECTIONS FOR USING ARSENATE OF LEAD.

Many experiments have shown that well-made arsenate of lead is much the safest of all available arsenicals for use on the peach. Arsenate of lead is to be found on the market both as a powder and as a putty-like paste. The latter must be worked free in water before it is added to the lime-sulphur mixture. The poison is used at the rate of about 2 pounds of the paste form or 1 pound of the powdered form to each 50 gallons of the lime-sulphur wash and is added, after it has been well worked free in water, to the lime-sulphur spray previously prepared. As there are numerous brands of arsenate of lead upon the market, the grower should be careful to purchase from reliable firms. A decided change in color will result when the arsenate of lead has been added to the lime-sulphur mixture, due to certain chemical changes which, in the experience of the writers, do not injuriously affect the fungicidal and insecticidal properties of the spray or result in injury to the foliage.

In large spraying operations it will be more convenient to prepare in advance a stock mixture of arsenate of lead, as follows: Place 100 pounds of arsenate of lead in a barrel, with sufficient water to work into a thin paste, diluting finally with water to exactly 25 gallons. When thoroughly stirred, each gallon of the stock solution will thus contain 4 pounds of arsenate of lead, the amount necessary for 100 gallons of spray. In smaller spraying operations the proper quantity of arsenate of lead may be weighed out as needed, and thinned with water. In all cases the arsenate of lead solution should be strained before or as it is poured into the spray tank. The necessary care should be exercised to keep the poison out of the reach of domestic and other animals.

DANGER OF INJURY FROM SPRAYING.

As stated elsewhere in this bulletin, the foliage of the peach is extremely sensitive to injury from such sprays as Bordeaux mixture and arsenicals, such as Paris green, arsenate of lead, etc. This sensitiveness has been the sole reason that it has been impracticable to spray peach orchards with fungicides and insecticides such as Bor-

deaux mixture or Paris green, as has been the custom for years in the case of apples, grapes, and other deciduous fruits.

Of the various arsenicals available for use, well-made arsenate of lead has proved to be the safest. Shortly after the development of this comparatively new insecticide it was at once extensively experimented with on peaches by numerous entomologists and it was tried to a limited extent by peach growers. A single application of arsenate of lead in water did not result in injury so important as to prevent its use. However, when two or three applications were made, as is necessary in the control of the curculio, serious shot-holing and falling of the leaves and even burning of the fruit resulted, the latter, in extreme cases, falling to the ground. The use of lime with arsenate of lead lessened the danger of injury considerably, but even when used in this way for two or three treatments, especially under certain weather conditions, extensive injury to foliage and fruit resulted.

When it was established that the self-boiled lime-sulphur wash was an effective fungicide and entirely safe as a spray for the peach, one of the interesting questions presented was whether arsenate of lead might be safely used with it to effect a combination spray for both insects and diseases. While on chemical grounds it appeared that the addition of arsenate of lead to the self-boiled lime-sulphur mixture would result in an important decomposition of the spray and greatly add to its probable injurious character, in practice the combined spray was found to be entirely safe. Observations extending over three seasons have failed to show any serious injury resulting from the use of this spray, even when as many as three applications have been made. Thus, in the test of numerous brands of arsenate of lead at Barnesville, Ga., during 1910, carried out by Mr. E. W. Scott, of the Bureau of Entomology, peach trees were given three thorough applications: (1) With arsenate of lead in limewater at the rate of 2 pounds to 50 gallons, and (2) with the self-boiled lime-sulphur wash used at the same strength. In all cases very serious injury resulted to fruit and foliage on the plats sprayed with the arsenate of lead in limewater, whereas there was no discernible injury on the plats treated with arsenate of lead in the self-boiled lime-sulphur wash. Why the arsenate of lead apparently loses its injurious properties when used in the self-boiled lime-sulphur wash is not understood, although its safe employment in this way is most fortunate.

In the schedule of applications only two arsenate of lead treatments are recommended, as these will measurably control the curculio and a third treatment would increase considerably the danger of injury. Where the curculio is very destructive, however, the grower should use his judgment as to whether a third application of the poison would be advantageous.

The effect of the arsenate of lead upon the fruit is to increase its color notably. This increase in color from two applications in self-boiled lime-sulphur wash improves the appearance of the fruit. Three or even two applications of the poison, alone or in limewater, however, result in a very excessive reddening, especially on the side exposed to the sun, on which later may appear brown, sunken spots of variable size, accompanied with more or less extensive cracking of the skin. This condition of the fruit is shown in figure 11.

The self-boiled lime-sulphur mixture when properly prepared according to directions does not injure the fruit or foliage, but if allowed to remain hot in concentrated form before dilution enough sulphur may go into solution to produce injury to the foliage. Users of this spray should therefore follow carefully the directions given for its preparation, bearing in mind that a good mechanical mixture of the sulphur and lime suspended in water and only slightly combined is desired rather than the solution of any considerable quantity of the sulphur.

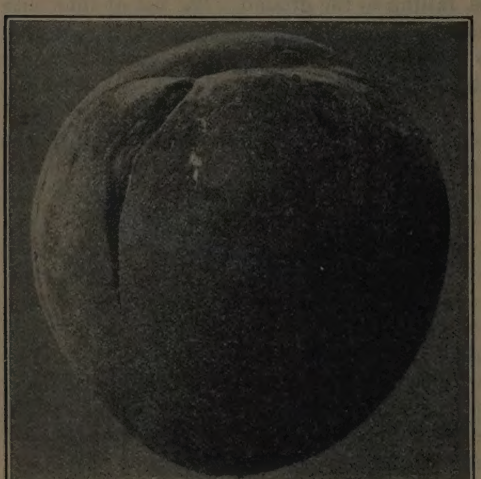


FIG. 11.—Elberta peach sprayed three times with arsenate of lead, showing the cracking effect of the poison.

During the application of the spray it is very important that the mixture be kept well agitated to insure its uniform distribution. As both the self-boiled lime-sulphur wash and the arsenate of lead quickly settle when the spray is left undisturbed, an excessive amount may be applied to some trees while others receive an insufficient quantity. While most spraying equipments are supplied with adequate agitating apparatus, the orchardist should assure himself that the spray is being properly stirred in the tank during its application. Under conditions of imperfect agitation and consequent settling, the ingredients of the spray may be applied so strong that serious injury will result. This has been observed to be the case, especially following the employment of compressed-air sprayers with inefficient agitators.

SCHEDULE OF APPLICATIONS.

Most of the peach orchards in the eastern half of the United States should be given the combined treatment for brown-rot, scab, and curculio. This is particularly true of the southern orchards, where all these troubles are prevalent. In some of the more northern orchards the curculio is not very troublesome, but as a rule it will probably pay to add the arsenate of lead in at least the first lime-sulphur application.

The self-boiled lime-sulphur mixture referred to in the following outlines of treatment should be made of a strength of 8 pounds of lime and 8 pounds of sulphur to each 50 gallons of water, and the arsenate of lead should be used at the rate of 2 pounds to each 50 gallons of the mixture or of water. When the poison is used in water there should be added the milk of lime made from slaking 2 to 3 pounds of good stone lime. When used in the lime-sulphur mixture additional lime will not be necessary.

Midseason varieties.—The midseason varieties of peaches, such as Reeves, Belle, Early Crawford, Elberta, Late Crawford, Chairs, Fox, and Beers Smock, should be sprayed as follows:

(1) With arsenate of lead and lime, about 10 days after the petals have fallen, or at the time the calyces are shedding. (Fig. 12.)

(2) With self-boiled lime-sulphur and arsenate of lead, two weeks later, or four to five weeks after the petals have been shed.

(3) With self-boiled lime-sulphur alone, four to five weeks before the fruit ripens.

Late varieties.—The Salway, Heath, Bilyeu, and varieties with a similar ripening period should be given the same treatment prescribed for midseason varieties, with an additional treatment of self-boiled lime-sulphur alone, to be applied three or four weeks after the second application.

Early varieties.—The Greensboro, Carman, Hiley, Mountain Rose, and varieties having the same ripening period should receive the first and second applications prescribed for midseason varieties.

Where the curculio is not particularly bad, as in Connecticut, western New York, and Michigan, the first treatment, which is for this insect only, may be omitted. Also for numerous orchards throughout the Middle States where the insect, especially in the younger orchards, is not yet very troublesome, orchardists should use their judgment as to whether the first application may be safely omitted. Where peach scab is the chief trouble, and brown-rot and the curculio are of only minor importance, as may be the case in some of the Allegheny Mountain districts, satisfactory results may be had from two applications, namely, the first with self-boiled lime-sulphur and arsenate of lead four to five weeks after the petals have fallen,

and the second treatment of the foregoing schedule with self-boiled lime-sulphur alone three to four weeks later. These two treatments, if thoroughly applied, will control the scab and brown-rot, especially on the early and midseason varieties, and will materially reduce

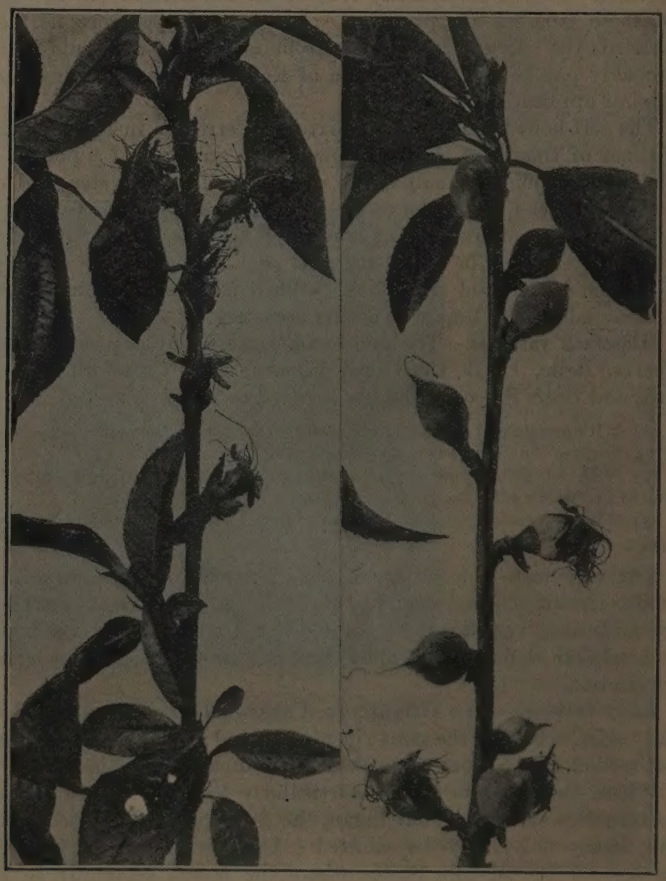


FIG. 12.—Young peaches, showing the earliest and latest stages at which the first arsenate of lead treatment should be made.

curculio injuries. Even one application of the combined spray made about five weeks after the petals have fallen would pay well, although this is recommended only for conditions where it is not feasible to do more.